

September 1970

Seventh Quarterly Report

Covering Period of 1 July 1970 to 1 October 1970

The Study of Synchronization Techniques
For Optical Communications Systems

Robert M. Gagliardi
Principal Investigator

Department of Electrical Engineering
University of Southern California
Los Angeles, California 90007



This work was sponsored by the National Aeronautics and Space Administration, under NASA Contract NGR-05-018-104. This grant was part of the research program at NASA's Goddard Space Flight Center, Greenbelt, Maryland.

FACILITY FORM 602

N71-70622	
(ACCESSION NUMBER)	(THRU)
4	
(PAGES)	(CODE)
C2-116202	
(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

This document represents the seventh quarterly report of a NASA Research Program to study synchronization techniques for optical communication systems. The work is being carried out at the Electrical Engineering Department at the University of Southern California, under NASA Contract No. NGR 05-018-104 with Professor R. M. Gagliardi as principal investigator. This grant began as part of the research program at NASA's Goddard Space Flight Center, Greenbelt, Maryland.

This study program is devoted to an investigation of problems associated with synchronizing an optical communication system. The objective of the effort is to indicate design procedures, assess system performance, and predict future areas of needed study in synthesizing and improving system operation. The organization and guideline of the study, the particular problem areas, and their applications are covered in the first quarterly report, March, 1969.

The research effort is primarily analytical in nature, and is divided into two categories. The first involves tasks with direct application to the synchronization problem, while the second involves related areas also being studied under the grant. This document reports technical progress during the sixth quarter, but detailed results will be published in separate interim reports, and are omitted here.

Current Progress

During the quarter two technical reports of study work have been published, summarizing earlier investigations:

- 1) Optical Synchronization - Phase Locking with Shot Noise Processes
authors R. Gagliardi and M. Haney USCEE Report 396, August, 1970.

Abstract

This report represents the results of a study effort examining time synchronization in an optical communication system. Consideration is given primarily to time locking by means of a phase lock tracking loop. Since photo-detection of an intensity modulated optical beam produces a shot noise random process at its output, synchronization analysis requires a study of phase locking with shot noise processes. A statistical analysis of tracking shot noise is presented. Of particular interest is the probability density of the tracking error, which indicates the behavior of the loop during tracking, and therefore is directly related to the ability to maintain accurate synchronization. The results of the study also have application to ranging and doppler tracking using optical systems.

- 2) Communication Theory for the Free Space Optical Channel authors R. M. Gagliardi (USC), S. Karp (ERC), E. O'Neill (Worcester Poly), USCEE 397, August, 1970. This report will be published as an invited paper in the IEEE special issue on Optical Communications, October, 1970.

Abstract

The objective of this paper is to summarize the current understanding of quantum detectors the noise mechanisms which limit (are basic to) their operation, and their application to optical communication (theory). In this context, we consider channels in which the electromagnetic field is not subjected to any propagation effects other than a geometric loss. (Such a channel would exist between satellites.) Optimum time processing using the tools of statistical communication theory is presented.

The following reports summarizing other recent technical work are presently in progress:

- 1) Counting Statistics with Extended Optical Detectors authors, R. Gagliardi, U. Farrukh.
- 2) Narrow Band Optical Detection - Laguerre Detection Theory authors R. Gagliardi, N. Mohanty.

Recent research primarily devoted to study in the following areas:

- 1) Computation of error probabilities associated with Laguerre counting statistics. A computer program has been prepared to plot error probabilities for all possible significant operating conditions. The results here will be particularly applicable to the study of digital optical systems at extremely high information rates (when the information bandwidth approaches the optical bandwidth).
- 2) Effect of imperfect synchronization on digital optical systems. Using the aforementioned computer program the results can be modified to account for imperfect time synchronization in the overall system.
- 3) Channel capacity of an optical communication link. This area affords a theoretical approach to the assessment of synchronization techniques to an overall optical communication system.